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CO₂ Storage via EOR Process

Statistical Analysis of CO₂ EOR Production and Injection Data to Examine Ongoing and Ultimate CO₂ EOR Incidental Storage

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Overview

- Statistical analysis of an industry data set
- 31 CO₂ enhanced oil recovery (EOR) sites
 - CO₂ injected (total) and CO₂ produced (recycle)
 - H₂O injected (WAG injection method)
 - Incremental oil recovery
 - In-fill drilling contributions subtracted from the total oil production to determine the incremental EOR production wedge resulting from CO₂ injection.
- Focused on 3 metrics:
 - CO₂ retention (% retained)
 - Incremental oil recovery (%OOIP)
 - Net CO₂ utilization (Mscf/STB)

Definition: CO₂ Retention

$$\text{CO}_2 \text{ Retention} = \frac{(\text{CO}_2 \text{ Injected} - \text{CO}_2 \text{ Produced})}{\text{CO}_2 \text{ Injected}}$$

Where:

CO₂ retention = percent of CO₂ retained [%];
CO₂ injected = total injected volumes (purchased + recycled CO₂) [%HCPVI];
CO₂ produced = total produced volumes (recycled CO₂) [%HCPVI].

Surface CO₂ losses would be subtracted from the numerator, as they represent a component of the CO₂ stream that leaves the system and is not recycled.

Our approach does not assume an average CO₂ loss across projects and does not subtract this constant from any calculations of CO₂ retention.

Definition: Net CO₂ Utilization

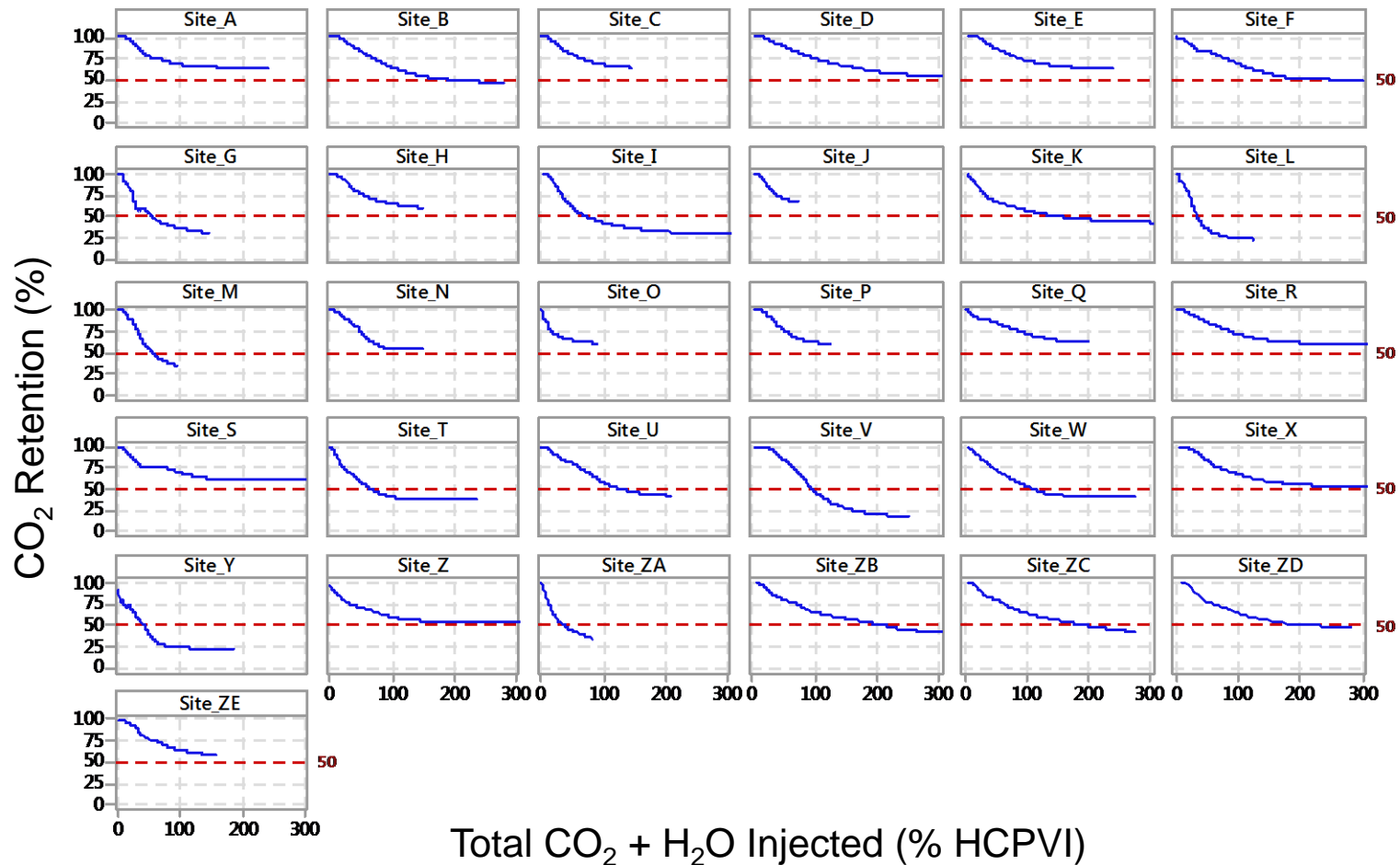
$$\text{CO}_2 \text{ UF}_{\text{net}} = \frac{V_{\text{CO}_2, \text{purchased}}}{N_p}$$

Where:

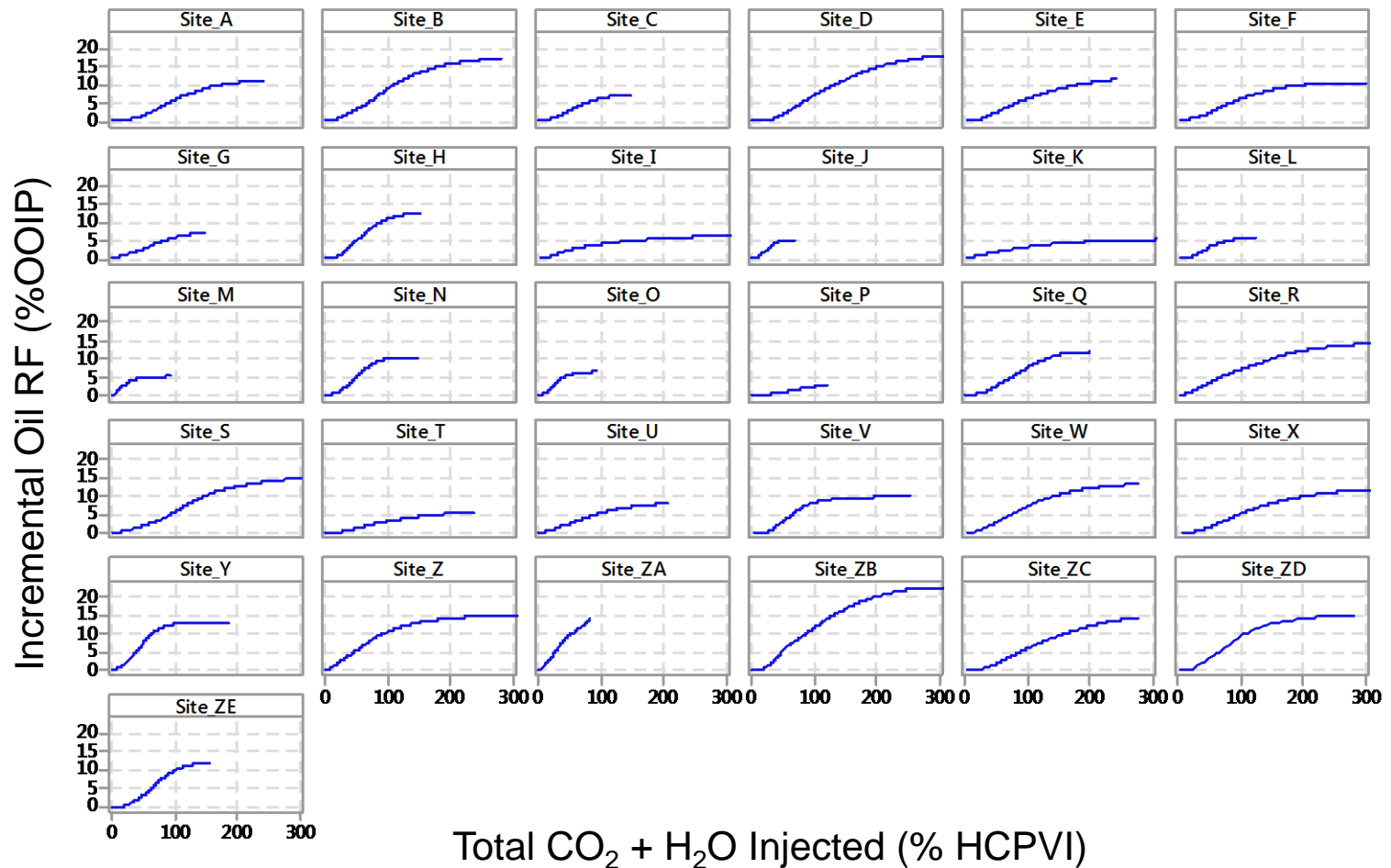
$\text{CO}_2 \text{ UF}_{\text{net}}$ = net CO₂ utilization factor [Mscf/STB];
 $V_{\text{CO}_2, \text{purchased}}$ = volume of CO₂ injected (purchased) [Mscf];
 N_p = incremental oil production [STB].

The net CO₂ utilization factors computed in this document are *cumulative* net CO₂ utilization factors, where the cumulative CO₂ injected is divided by the cumulative incremental oil produced up to the %HCPVI that was selected for the calculation.

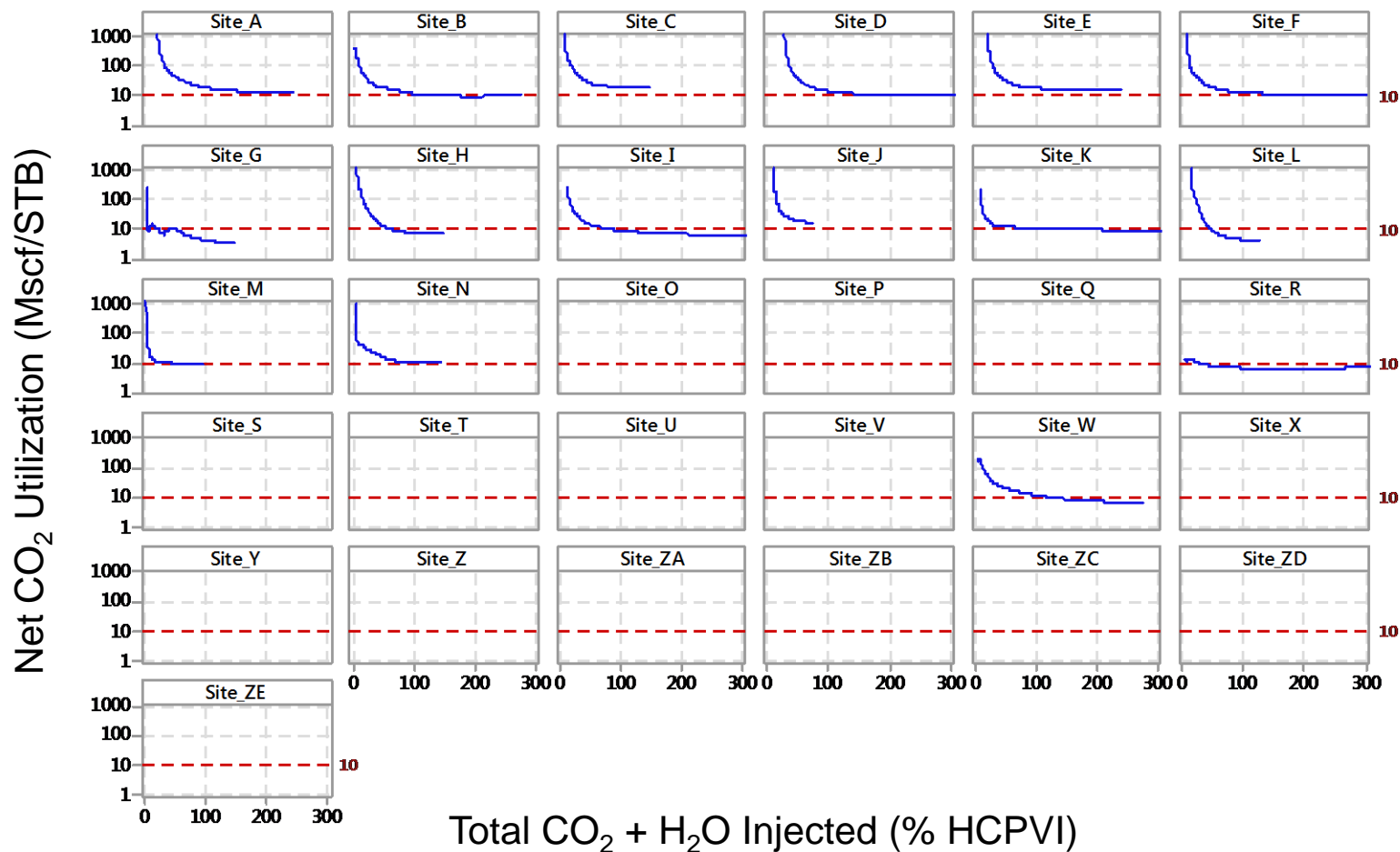
Measured Data: CO₂ Retention



Measured Data: Incremental Oil RF



Measured Data: Net CO₂ Utilization

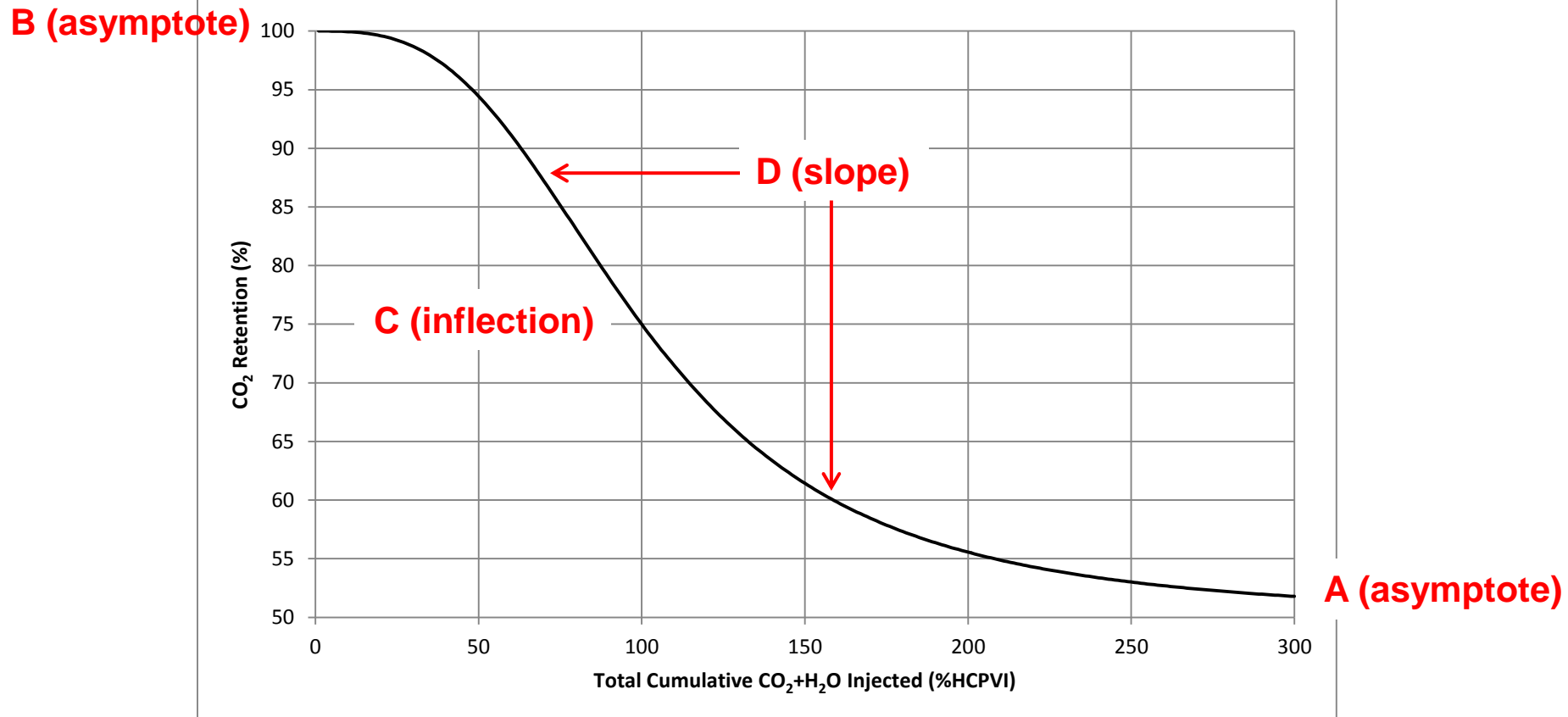


Nonlinear Regression Objectives

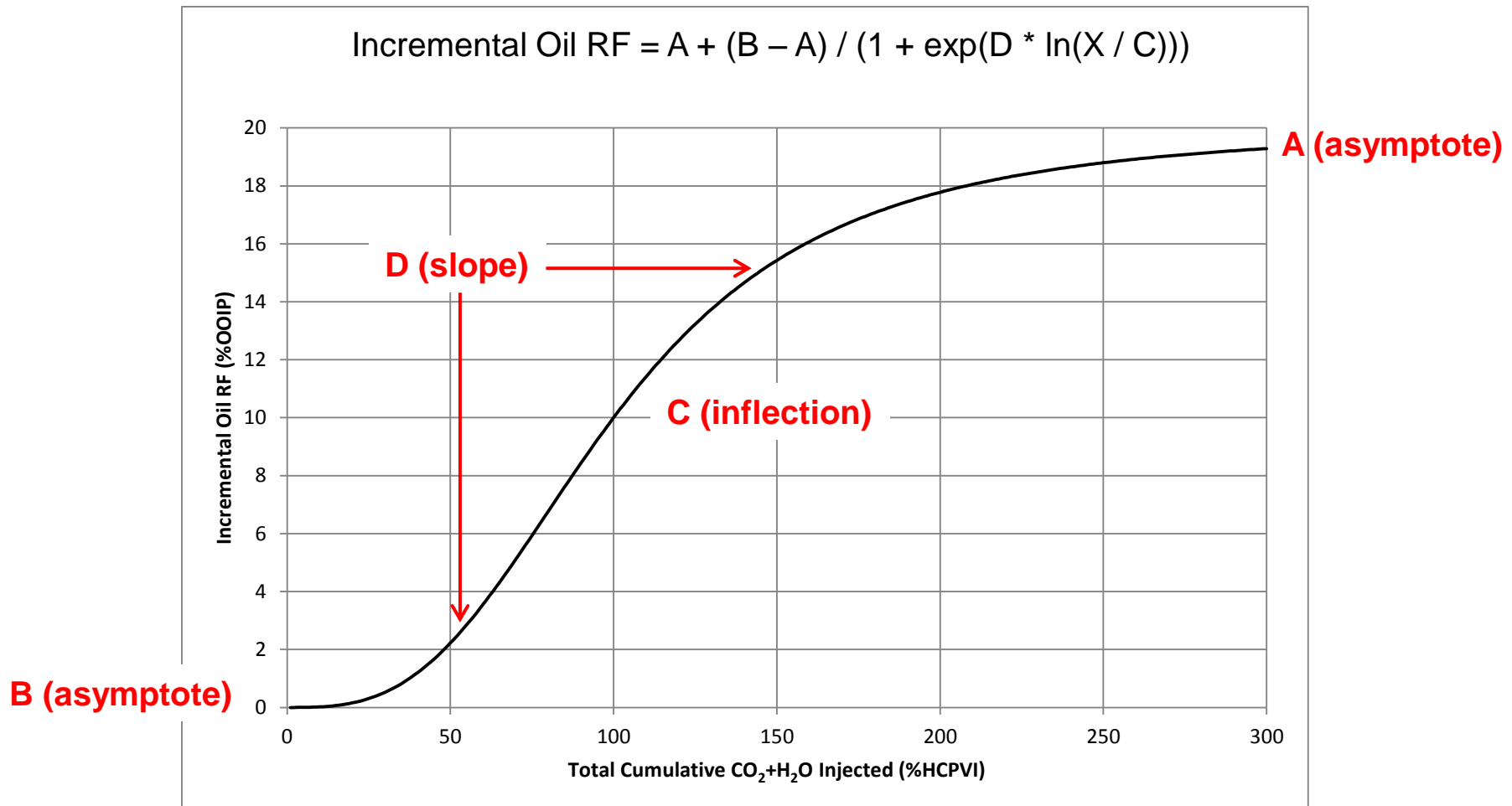
- Extend measured data to 300% HCPVI across sites
- Quantify uncertainty from 50%-300% HCPVI
- Draw inferences across sites from model parameters
- Extend empirical approaches to supplement additional screening-level assessments for estimating the potential range of expected performance for candidate oil fields that are not currently under CO₂ injection.

Four-Parameter Log-Logistic: CO₂ Retention

$$\text{CO}_2 \text{ Retention} = A + (B - A) / (1 + \exp(D * \ln(X / C)))$$

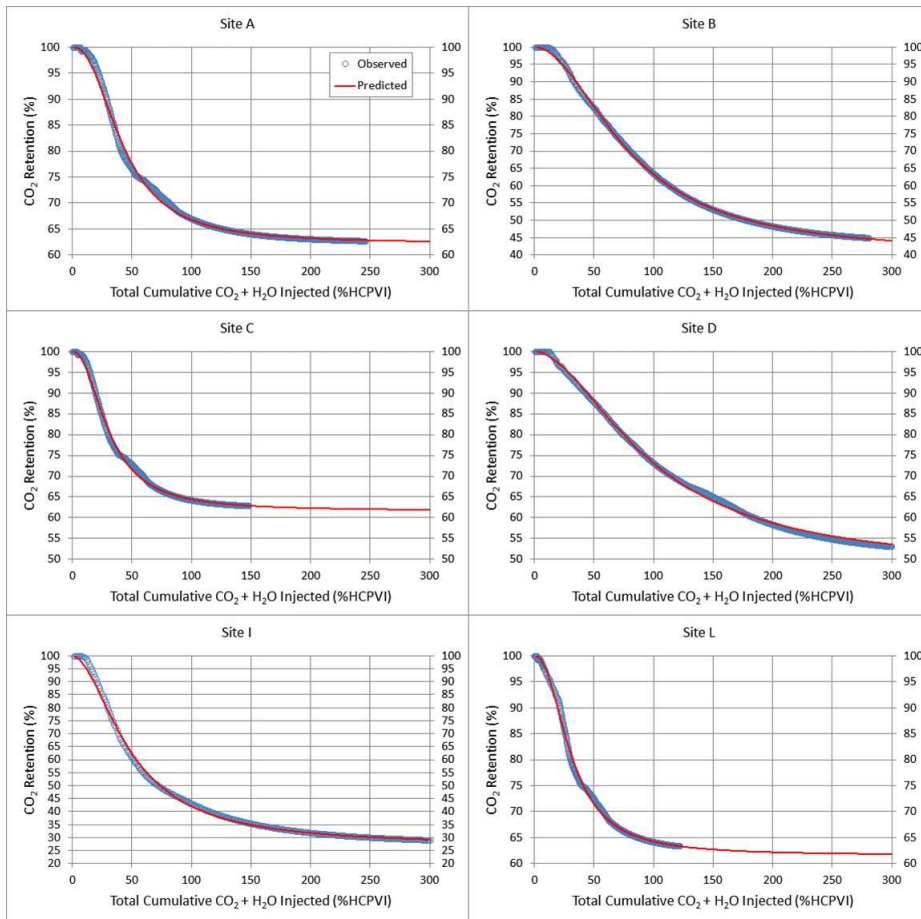


Four-Parameter Log-Logistic: Incremental Oil RF

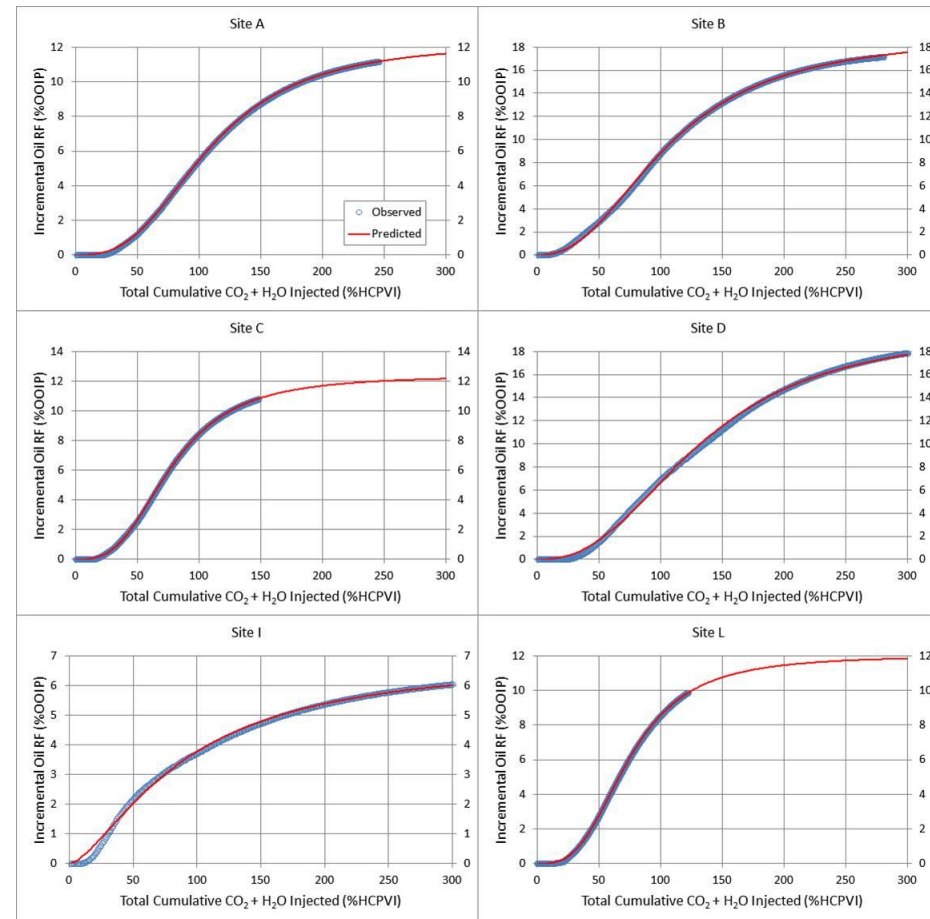


Excellent Model Fits Across Data Record

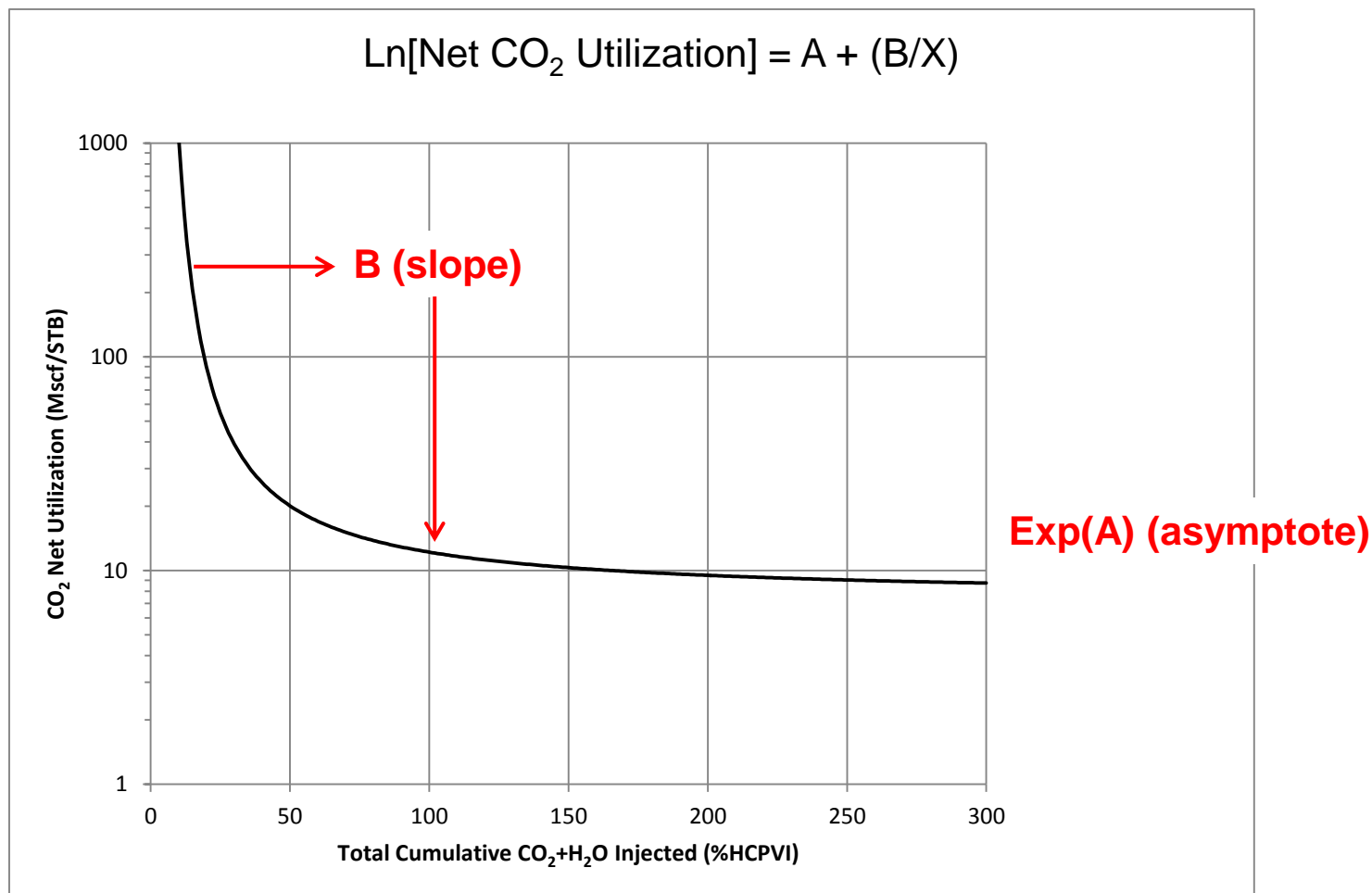
CO₂ Retention



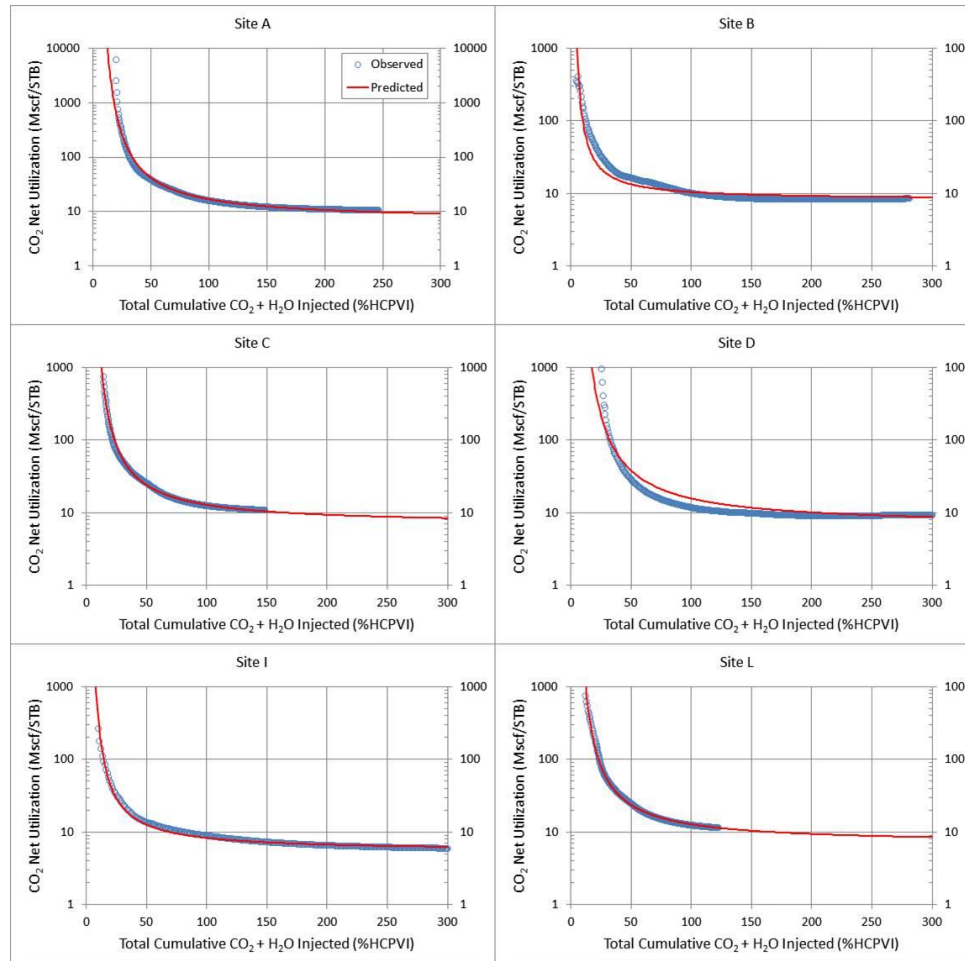
Incremental Oil RF



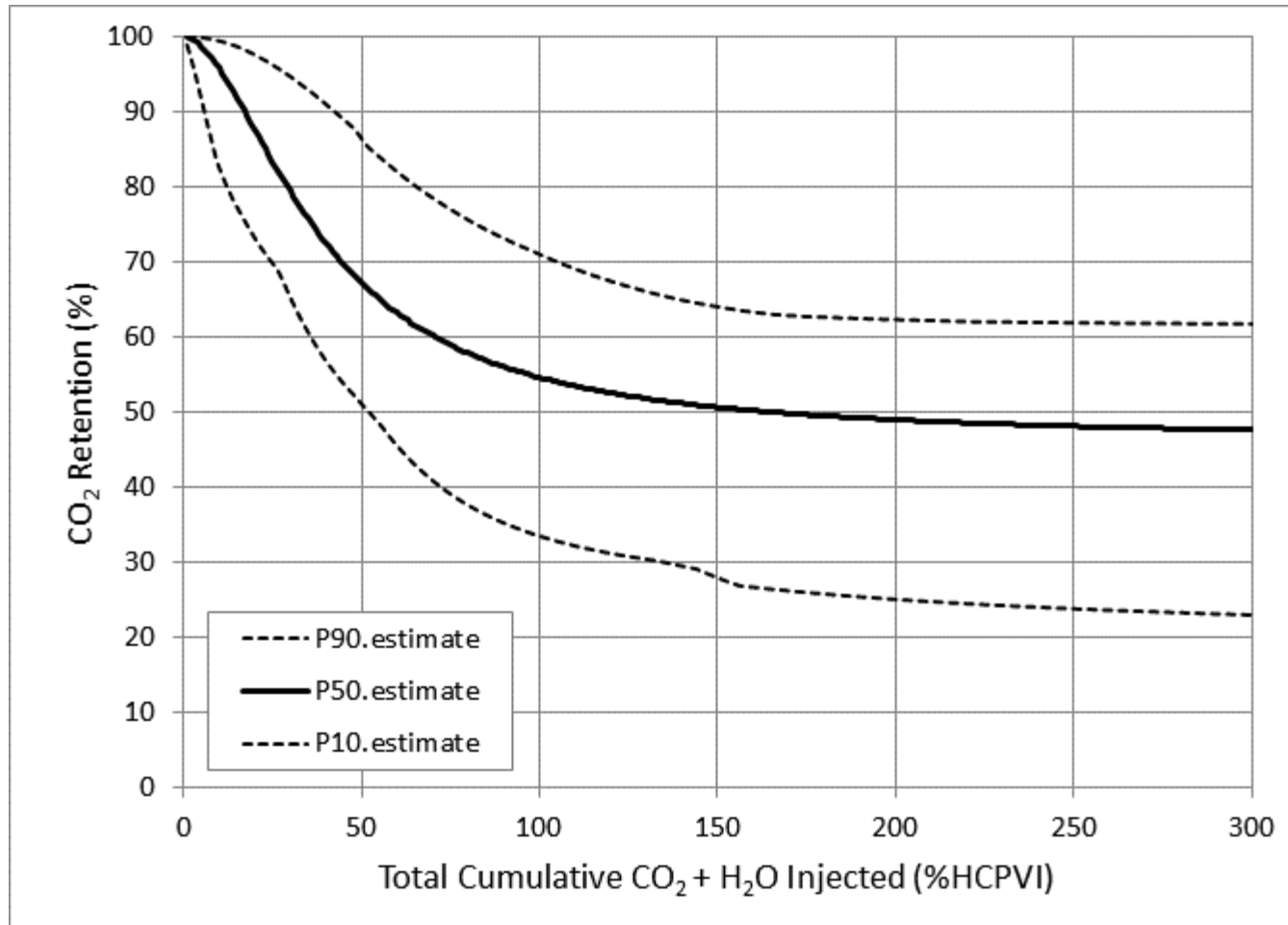
Asymptotic Function: Net CO₂ Utilization



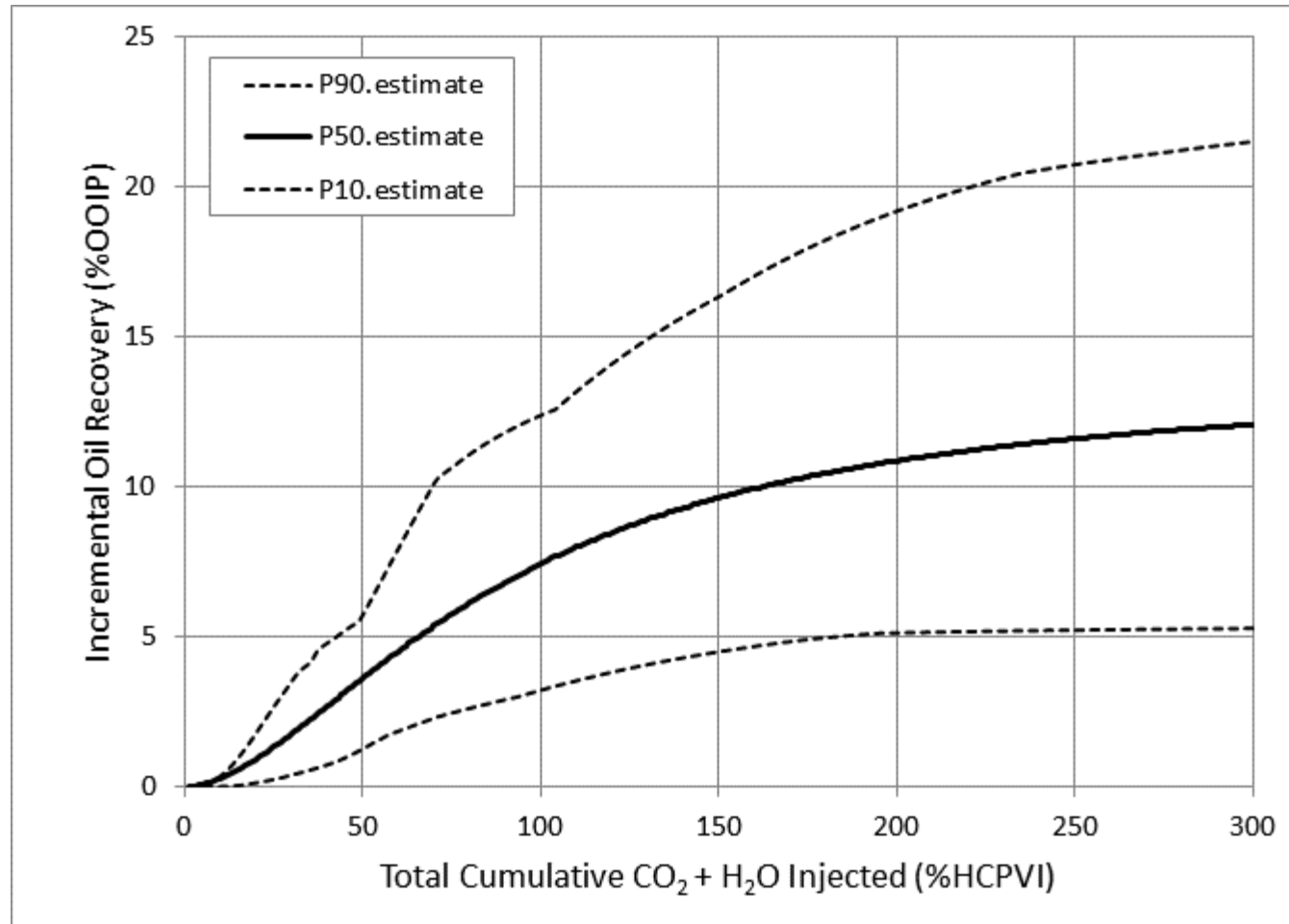
Accurately Describes the Overall Shape of the Net CO₂ Utilization Response



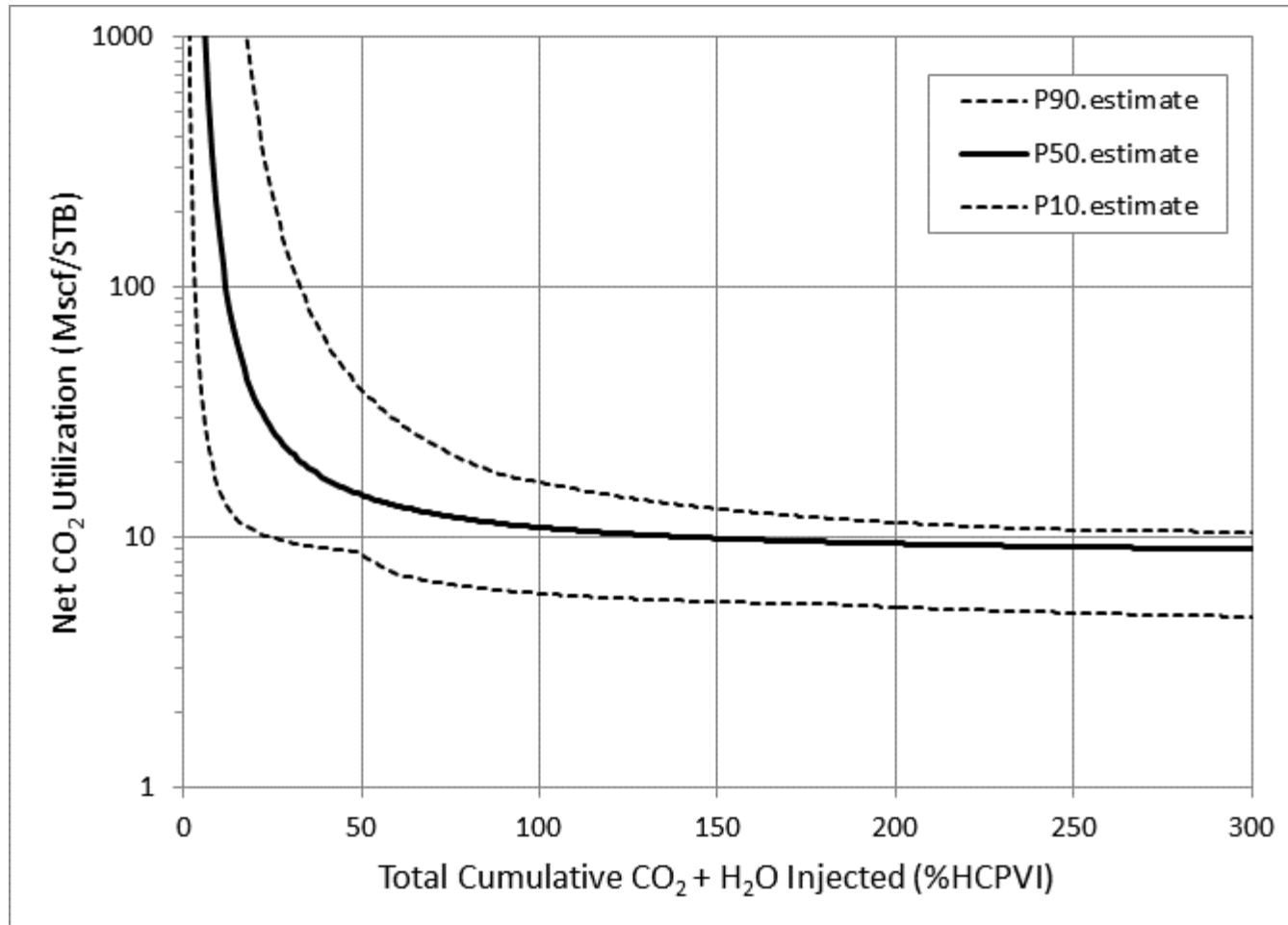
Uncertainty Quantification: CO₂ Retention P10, P50 and P90



Uncertainty Quantification: Incremental Oil RF P10, P50 and P90



Uncertainty Quantification: Net CO₂ Utilization P10, P50 and P90



Summary

- The P10, P50, and P90 at 300% HCPVI estimates for
 - CO₂ retention = 23.1, 48.3, and 61.8 % retention
 - Incremental oil recovery = 5.3, 12.1, and 21.5 % OOIP
 - Net CO₂ utilization = 4.5, 8.7, and 10.5 Mscf/STB.
- Four-parameter log-logistic function was able to accurately describe the overall shape of the CO₂ retention and incremental oil recovery curves.
- Two-parameter asymptotic function was able to accurately describe the overall shape of the net CO₂ utilization curves.
- Additional investigation into the factors that control the parameters of the log-logistic or simple asymptotic functions may yield additional screening tools that can be used to assess the potential range of expected performance for candidate oil fields that are not currently under CO₂ injection, including estimates of the incidental CO₂ storage potential.

Project Partners



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